ORIGINAL ARTICLE
SCIENCE OF MARTIAL ARTS

The effects of impact forces and kinematics of two different stances at straight punch techniques in boxing

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Bergun Meric Bingul[1ABCDE], Cigdem Bulgan[2ABDE], Ozlem Tore[1BD], Mensure Aydin[1D], Erdal Bal[1BDE]

[1] Faculty of Sport Science, Kocaeli University, Kocaeli, Turkey
[2] The School of Physical Education and Sport, Halic University, Istanbul, Turkey

Received: 18 September 2017; **Accepted:** 21 November 2017; **Published online:** 27 December 2017

AoBID: 11758

Abstract

Background & Study Aim: The punch is a key component of boxing. In scientific papers, there is information about kinematic indicators and impact forces. It mentioned that lower extremity has a strong effect on impact force, through transferring momentum into the kinetic chain system. However, the differences of impact forces in different boxing posture have not been fully investigated. The aim of the study was the effects of impact forces and some kinematic indicators in boxing both orthodox and southpaw stance of straight punch technique.

Materials & Methods: Nine light middleweight elite boxing athletes from the Turkish National Team (mean and SD): age 19.33 ±2.11yrs; height 174.22 ± 3.79cm; weight 66.0 ±6.62 kg. All participants had experienced both national and international tournament. The techniques were recorded at a frequency of 120 Hz using eight synchronised high-speed cameras (Oqus 7+). The cameras were placed, approximately at right- angles to one another. The three-dimensional data were analysed using Qualisys Track Manager (Qualysis, Sweden). This system provides clean and accurate 3D data. A carbon fibre L-frame and a wand calibration stick (600 mm) were used to calibrate the 3D performance area.

Results: There was a statistically significant difference only in the trunk angle on the sagittal plane (YZ) ($p = 0.015$) and no any statistical differences in other angular indicators. There was a statistical difference in sandbag acceleration between southpaw and orthodox stances ($p = 0.05$). Also, it was found that significant differences in punch velocity ($p = 0.038$) and punch acceleration ($p = 0.021$). Additionally, significant differences were found in impact force values and impulse values according to the stance positions ($p = 0.05$).

Conclusions: The boxing athletes achieved more impact forces and accelerations in the orthodox stance. It is recommended that to use an orthodox stance instead of southpaw stance in straight punch technique especially for creating more impact forces.

Keywords: orthodox stance • punch acceleration • punch velocity • southpaw stance • technique

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: The research was approved by the local Ethics Committee

Provenance & peer review: Not commissioned; externally peer reviewed

Source of support: Departmental sources

Author's address: Cigdem Bulgan, School of Physical Education and Sport, Halic University, TSYD Campus, Levent Caddesi No 51, Istanbul, Turkey; e-mail: cigdembulgan@halic.edu.tr

Kinematics – *noun* the scientific study of motion [19].

Impact force – *noun* a force that is a result of colliding with another body, e.g. when a runner's foot hits the ground. Compare **active force** [19].

Punch – *verb* to strike someone or something with the fist, e.g. in boxing or martial arts [19].

Technique– *noun* a way of performing an action [19].

Technique – specific procedures to move one's body to perform the task that needs to be accomplished [20].

Tactics – decisions and actions of players in the contest to gain an advantage over the opposing players [20].

INTRODUCTION

In combat sports, competition results are determined by a number of interrelated factors: motoric abilities, psychological capacity, technique, tactics, and the refereeing method [1]. The punch is a key component of boxing. It is used to create physical damage, improve tactical advantage and score points against an opponent. Punching is a complicated motion, and however, it contains some movement of the arm, trunk and legs, lower body is considered a main contributor to an effective punch [2]. The force of a punch delivered to a punching bag is a crucial element of special fitness [1].

The straight punch is an important score making punch type and very powerful ability that done with the rear hand in boxing. Done often with the dominant hand, the technique is very definite and could potentially change competition result [3]. The straight punch is a fast motion from the front hand delivered but weak throw. The punch starts with slightly bent knees, a push off the ball of the rear foot, while simultaneously rotating the hips. The torso follows that movement, with the extension of the rear shoulder and arm [4].

In boxing, boxers adopt one of two available stances in straight punching. One of them was orthodox, and the other one was a southpaw. The term "orthodox stance" refers to the positioning of the boxer's hands and feet with the left foot and left hand forward, and the right foot and right hand back – natural to a right-handed person. The term "southpaw", natural to left-handers, refers to having one's right foot and right hand in the front: a reverse of the orthodox stance [1, 5]. Especially in the preparation season, to make some biomechanical analysis of the punch techniques and types would be very helpful information to the athletes and coaches. It is known that which punches type and combinations can reach their intended target in the minimum time and also which generate the greatest impact force [6].

In the literature, kinematic indicators and impact forces have been measured [7-10]. It mentioned that lower extremity has a strong effect on impact force, through transferring momentum into the kinetic chain system [11]. However, the differences of impact forces in different stance position have not been fully investigated.

The aim of the study was the effects of impact forces and some kinematic indicators in boxing both orthodox and southpaw stance positions of straight punch technique.

MATERIAL AND METHODS

Participants

Nine light middleweight elite boxing athletes: mean age 19.33 ±2.11 years; height 174.22 ±3.79 cm; weight 66.0 ±6.62 kg, from the Turkish National Team, were recruited to participate in this study. All participants had experienced both national and international tournament. Also hey had no any extremity injury before.

This study was conducted in a manner consistent with the recommendations of the declaration of Helsinki. Each participant voluntarily provided written informed consent before participating.

Procedures

Straight punch techniques with two different stances (orthodox and southpaw) were analysed. A traditional orthodox stance is; the boxer places his left foot further in front of the right foot, thus having his weaker side closer to the opponent (Figure 1). Southpaw, the stance where the boxer has his right hand and right foot forward, leading with right jabs (Figure 2).

After 10 min warm-up and stretching, all athletes were performed with their maximum effort of straight right punch to the sandbag. They were tried introductory punches before the test to convince that no intolerable risk of injury was involved and in the test, they performed one trial with two different stance positions. Reflective markers were placed to the segments and joints' kinematics including the shoulders (acromion process), the elbows (lateral epicondyle of humerus), the wrists (styloid process of the radius), the first (second and fifth metacarpal distal head), the hips (iliac spines), the knees (lateral femoral epicondyle) and the ankles (lateral malleolus). Also, there were another eight markers were attached to the sandbag for determination of indirect impact forces (Figure 1 and 2).

The techniques were recorded at a frequency of 120Hz using eight synchronised high-speed cameras (Oqus 7+). The cameras were placed, approximately at right- angles to one another. The three-dimensional data were analysed using

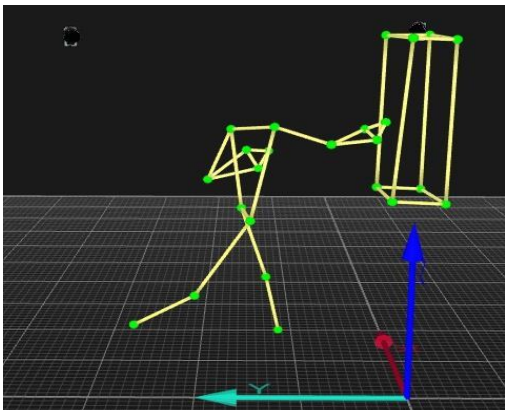

Figure 1. Orthodox stance

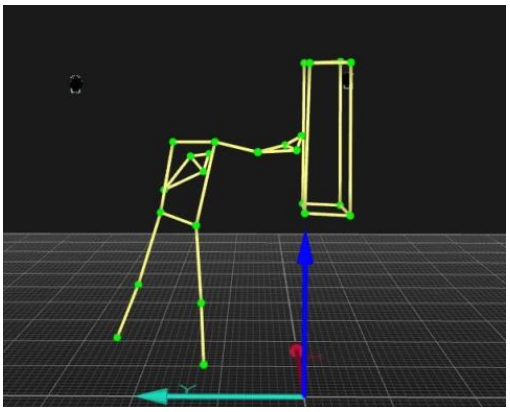

Figure 2. Southpaw stance

Qualisys Track Manager (Qualysis, Sweden). This system provides clean and accurate 3D data [3]. A carbon fibre L-frame and a wand calibration stick (600 mm) were used to calibrate the 3D performance area.

The mean velocity and acceleration of the punch; mean acceleration of the sandbag and angles of the trunk, shoulder, hip and knee were calculated for all boxing athletes. Forces were calculated with using sandbag mass (48.80 kg) by the formula of $F = m \cdot a$ and impulse were calculated by the formula of $F.\Delta t$.

Statistical analysis

Kinematic data statistics were done by using SPSS 20.0 (SPSS Inc., Chicago, USA) software and Microsoft Excel 2011, version 14.6.7 were used for indirect calculation of the impact forces. Means and standard deviations were calculated for all variables, and the straight punch techniques' data were compared with Wilcoxon test. The level of significance was set at $p<0.05$.

RESULTS

There was a statistically significant difference only in the trunk angle on the coronal plane (YZ) ($p = 0.015$) and no any statistical differences in other angular indicators (Table 1). There was a statistical difference in sandbag acceleration between southpaw and orthodox stances ($p = 0.05$). Also, it was found that significant differences in punch velocity ($p = 0.038$) and punch acceleration ($p = 0.021$). Additionally, significant differences were found in impact force values and impulse values according to the stance positions ($p = 0.05$) (Table 2).

DISCUSSION

The present study was aimed to investigate the differences of some kinematic and kinetic indicators between two stance positions during straight punch in boxing. The velocities, accelerations and forces of the punch and sandbags and also some segment angles at impact were

Table 1. The mean and standard deviations (±) of the angles of the trunk, shoulder, hip and knee for both stance of light middleweight elite boxing (n = 9).

Variable		Stance	
Angle of body part (°)	Body planes	Southpaw	Orthodox
Knee		162.11 ±8.88	162.89 ±7.89
Trunk	YZ	−34.44 ±8.40	**−48.1 ±7.47***
	XZ	−25.89 ±51.13	−39.44 ±8.22
	XY	6,89 ±5.11	10.56 ±3.84
Shoulder		83.56 ±8.02	84.33 ±8.93
Hip		156.67 ±6.71	163.89 ±8.51

*$p<0.05$; **YZ** coronal; **XZ** sagittal; **XY** transverse

Table 2. The mean and standard deviations (±) of the velocity and accelerations of the punch and sandbag of light middleweight elite boxing (n = 9).

Variable	Southpaw Stance	Orthodox Stance
Sandbag velocity (m/s)	0.51 ±0.11	0.58 ±0.17
Sandbag acceleration (m/s^2)	33.13 ±8.91	**40.73** ±7.00*
Punch velocity (m/s)	4.18 ±1.2	**5.34** ±1.38*
Punch acceleration (m/s^2)	328.09 ±65.83	**424.67** ±104.94*
Impact forces (N.m)	1616.96 ±434.92	**1987.42** ±341.95*
Impulse (N.m/s)	27.00 ±7.26	**33.19** ±5.71*

*p<0.05

calculated. According to the results of the present study, there were statistical differences were found in trunk angle between stances (p = 0.015). In orthodox and southpaw stances have their stand positions, so the trunk position needs to change regarding this stand. This difference was expected result in the study.

It was mentioned that the hand velocity and punch forces correlated more strongly [2, 4 see also 12]. Whiting et al. [13] in 1988 calculated average velocities at contact ranged from 5.9 to 8.2m/s with peak velocities of 6.6 to 12.5m/s reached 8 to 21m/s prior to hand/glove contact with the sandbag. Kimm and Thiel [4], determined the hand peak velocity as high as 9 m/s depending on the type of punch: jab, cross, lead hook and reverse hook. Additional researches were measured that single maximal punch contact speed at 8.16 m/s [14]. Itwere obtained the first velocity between 6.17 and 7.29 m /s for jab applied in semi-contact style and fist velocity in the range from 6.95 to 7.93 m /s semi-contact cross [15]. In the present study, punch velocities were found 4.18 and 5.14m/s respectively for a southpaw and orthodox stances. These results were lower when it compared to the literature. The result of this might be the athletes' level.

Some of the studies have mentioned that the boxers' victory during competition is paramount by punching force. There are three main contributors of punching force that coming from a rear hand: (a) the contribution of the arm muscles, (b) the trunk rotation, and (c) the drive off the ground [16]. Most of the studies were primarily investigated on forces in punching throw [2, 8, 11]. Pierce et al. [17] informed that the mean punch forces ranged from 866.6N (super middleweight) to 1149.2N (light middleweight) across the fights. The greatest mean punch forces observed in boxers of a light middleweight (1149.2N) and a light welterweight (1124.3N) by them. Conversely, the lowest mean punch forces were by boxers a super middleweight at 866.6N and a cruiserweight at 920.5N. The maximum strength varied between 761 and 1162N. These results are lower than those obtained by Walilko et al. [14] that are between 1990 and 4741N and those obtained by Dyson et al. [18] (between 2471 and 4236N).

Chadli and Ababou [11] were found the forces 4800 ±227N, 3722 ±133N and 2381 ±116N for the rear hand, respectively for elite, intermediate and novice groups and these results were larger for the rear than the lead hand (p<0.001). Maximum punching force was greater in the elite group (p<0.05). Such a difference between the forces produced by the rear and lead hands may be related to the force generated by the legs Smith et al. [8] and Lenetsky et al. [2]. The boxers throw their punch, using the leg drive determined by lower body joints kinematics [3]. Size and musculature may determine the force that can be delivered [17], but stance positions likely change this force. In the present study, the impact forces were calculated as 1616.96±434.92N for southpaw stance and 1987.42±341.95N for orthodox stance. It was found the significant difference, and this difference in our opinion was mainly due to the lower punch velocity compared with those who participated in the testing of other researchers.

We believed that it was more force produced with the changing of trunk rotation angles. Force production was not only from the arm but also for

the opposite leg worked with the arm as a cross leg, the sign of the centre of gravity remains in the middle of the legs, and the dynamic equilibrium conditions were provided better. This situation can provide more defensive status than the production of offshore forces as well as the collateral damage. Sorokowski et al. [5] mentioned that each boxer had a preferred stance, which was usually determined by keeping the stronger hand in the back. They believed that because the stronger hand was used for delivering power punches that require more space, whereas the weaker hand, kept in the front, was used for quicker jabs intended to keep the opponent at bay and break down the defences [5].

CONCLUSIONS

The boxing athletes achieved more impact forces and accelerations in orthodox stance position. It is recommended that to use an orthodox stance instead of southpaw stance in straight punch technique especially for creating more impact forces.

REFERENCES

1. Buśko K, Staniak Z, Łach P et al. Comparison of two boxing training simulators. Biomed Hum Kinet 2014; 6(1): 135-141
2. Lenetsky S, Harris N, Brughelli M. Assessment and Contributors of Punching Forces in Combat Sports Athletes: Implications for Strength and Conditioning. J Strength Cond 2013; 35(2): 1-7
3. Cheraghi M, Agha Alinejad H, Arshi AR et al. Kinematics of Straight Right Punch in Boxing. Ann Appl Sport Sci 2014; 2(2): 39-50
4. Kimm D, Thiel DV. Hand Speed Measurements in Boxing. Proc Eng 2015; 112: 502-506
5. Sorokowski P, Sabiniewicz A, Wacewicz S. The influence of the boxing stance on performance in professional boxers. Anthropol Rev 2014; 77(3): 347-353
6. Piorkowski B, Lees A, Barton GJ. Single Maximal versus Combination Punch Kinematics. Sport Biomech 2011; 10(1): 1-11
7. Karpiłowski B, Nosarzewski Z, Staniak Z. A versatile boxing simulator. Biol Sport 1994; 11(2): 133-139
8. Smith MS, Dyson RJ, Hale T et al. Development of a boxing dynamometer and its punch force discrimination efficacy. J Sport Sci 2000; 18(6): 445-450
9. Nien YH, Chuang LR, Chung PH. The design of force and action time measuring device for martial arts. Int Sport Eng Assoc 2004; 5(2): 139-144
10. Falco C, Alvarez O, Castillo I et al. Influence of the distance in a roundhouse kick's execution time and impact force in Taekwondo. J Biomech 2009; 42(3): 242-248
11. Chadli S, Ababou N. A new instrument for punch analysis in boxing. Proc Eng 2014; 72: 411-416
12. Mack J, Stojsih S, Sherman D et al. Amateur boxer biomechanics and punch force. In: Jensen R, Ebben W, Petushek E et al., editors. ISBS-Conference Proceedings Archive. 28 International Conference on Biomechanics in Sports; 2010 Jul 19-23; Marquette, USA; Marquette: Northern Michigan University; 2010
13. Whiting WC, Gregor RJ, Finerman GA. Kinematic analysis of human upper extremity movements in boxing. Am J Sport Med 1988; 16(2): 130-136
14. Walilko TJ, Viano DC, Bir CA. Biomechanics of the head for Olympic boxer punches to the face. Brit J Sport Med 2005; 39(10): 710-719
15. Băiţel I, Deliu D. Kinematic aspects of direct punch cross and jab applied in semi-contact. Proc Soc Behav Sci 2014; 17: 335-340
16. Filimonov VI, Koptsev KN, Husyanov ZM et al. Means of increasing strength of the punch. Natl Strength Cond Assoc J 1983; 7: 65-66
17. Pierce JD, Reinbold KA, Lyngard BC et al. Direct measurement of punch force during six professional boxing matches. J Quant Anal Sports 2006; 2: 1-17
18. Dyson R, Smith M, Fenn U et al. Differences in Lead and Rear Hand Punching Forces, Delivered at Maximal Speed Relative to Maximal Force, by Amateur Boxers. In: Wang Q, editor. ISBS-Conference Proceedings Archive. 23 International Symposium on Biomechanics in Sports; 2005 Aug 22-27; Beijing, China; Marquette: Northern Michigan University; 2005
19. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006
20. Martens R. Successful Coaching. London: Human Kinetics; 2004

Cite this article as: Bingul BM, Bulgan C, Tore O et al. The effects of impact forces and kinematics of two different stances at straight punch techniques in boxing. Arch Budo Sci Martial Art Extreme Sport 2017; 13: 35-39